Space Weather Technical Forecast

Issued on Wednesday, 02 February 2022 at 01:04 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: Chance of G1-G2 Minor to Moderate Storms during day 1 (2nd February) from CME arrival. Chance M-flares (R1/R2 Radio Blackouts).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Low with a number of C-class flares observed, the majority of these originated from AR2940 (Dsc/Beta) near the northeast limb and AR2939 (Esi/Beta) in the southeast quadrant. Currently the largest region, AR2936 (Eho/Beta) produced the largest flare, with a C9 observed at 01/2236UTC, and associated plasma eruption. Awaiting coronagraph imagery to confirm a coronal mass ejection (CME). Two other sunspot regions are simple, stable alpha or small beta regions. No Earth-directed CMEs were observed in available imagery in the last 24 hours, although a few have launched off the west limb.

Solar Wind / Geomagnetic Activity: The solar wind, as observed at L1, slowly declined to around 400-450km/s, before the arrival of the CME (launched from the Sun on the 29th Jan) at L1, with a interplanetary shock (sudden impulse) observed at 01/2200UTC, with speeds increasing to 480km/s. Density has been below average, before rising to slightly above average, with the arrival of the CME. Total interplanetary magnetic field strength, Bt, was mostly weak, before suddenly increasing to moderate, with a peak of 14nT at 01/2300UTC, and the Bz was between +5nT and -3nT, before a sudden drop to -13nT at 01/2229UTC, associated with the arrival of the CME. The Phi angle was mostly positive (away from the Sun). Geomagnetic activity was mainly Quiet (Kp 1-2), with an Unsettled interval (Kp3) at 01/2100 to 02/0000UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) measured at GOES 16 was at background levels. The high energy electron flux (greater than 2MeV), started at moderate levels, before rising to high levels at the diurnal peak, with a peak value of 2130 pfu at 01/1730UTC. The associated 24-hour electron fluence has been steady just below the Active threshold (1e8 integrated flux), with 7.1e7 recorded at 02/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be mainly Low to Moderate, with a chance of isolated M-class flares, most likely from AR2939 and AR2940, but AR2936 still poses a threat as it becomes unstable. There is also a very slight chance (5%) of X-class flares from any of these three regions depending on how they develop over the coming days.

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 29 January arrived at Earth overnight on the 1st Feb, with its effects likely to continue into day 1 (2nd Feb). Solar winds are expected to be slightly elevated during day 1 (2nd Feb) after the arrival of the CME, before waning back to background levels on day 2 (3rd Feb) and into day 3 (4th Feb). Probably increasing to slightly elevated to elevated by day 4 (5th Feb) due to a fast wind from coronal hole 49. Geomagnetic conditions are likely to be enhanced, increasing to Unsettled to Active (Kp3-4) with a Chance of G1-G2 Minor/Moderate storm intervals (Kp5-6) during day 1 (2nd Feb). The solar wind should then wane again during 3rd and 4th February, but perhaps increasing again

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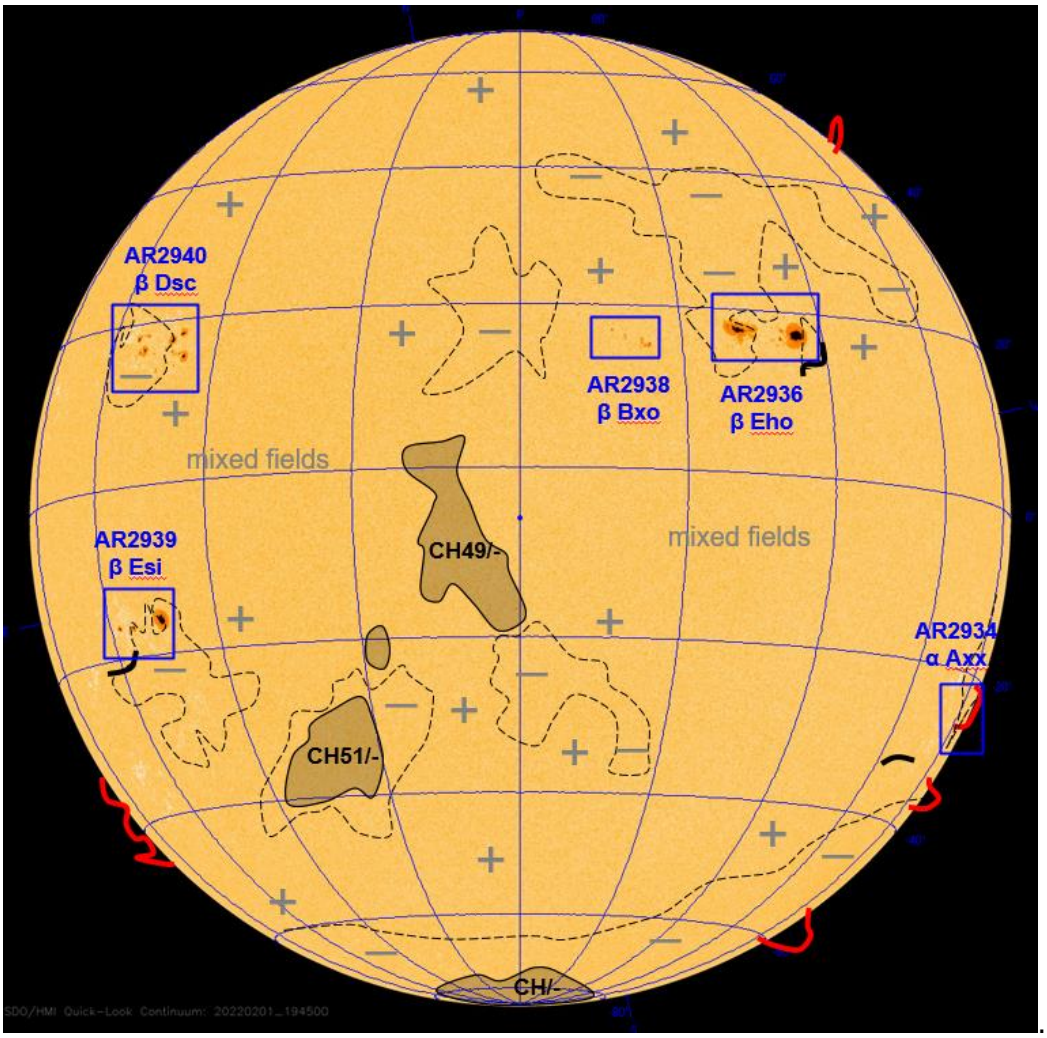
later on the 4th and into the 5th February due to coronal hole 49's high speed wind arriving at Earth.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is forecast to be at background levels but with a slight chance of rising close to or just above the S1 level, given any significant M-flaring, predominately from AR2936 if it remains unstable as it rotates across to the western limb. The high energy electron flux (greater than 2MeV) is likely to remain moderate, although with the arrival of the CME, its behaviour is uncertain over the coming days, but likely to see further drops in counts during day 1 (2nd Feb) as geomagnetic activity becomes enhanced. The electron fluence is expected to remain just below the Active (1e8 integrated pfu) threshold for the time being.

Figure 1. Solar Analysis Valid 01/1945UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A full halo CME (which is more directed at Stereo A) on 29 January arrived at Earth overnight on 1st February. A chance of G1 or G2 storming is possible as it passes the Earth, particularly if the magnetic orientation is favourable for geomagnetic connection. The winds should ease during 3rd and 4th but fast solar winds from Coronal Hole 49 are likely to arrive at Earth for the coming weekend, possibly later on day 4 (4th Feb) and into day 5 (5th Feb). This forecast is based on persistence and despite the hole being in a similar region of the Sun to the equivalent hole on the last rotation, there is some uncertainty in the actual timing. Speeds of 600km/s are possible.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	70	20	10	5
Strong	G3	No	10	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
30/0633	Full (Asymmetric)	AR2936	08N 10E	540km/s	02/0400 +/- 9 hours	CME reassessed 31st to be slightly slower

Figure 2: Real Time Solar Wind parameters (NOAA) shows a clear interplanetary shock in the magnetic field (yellow box)

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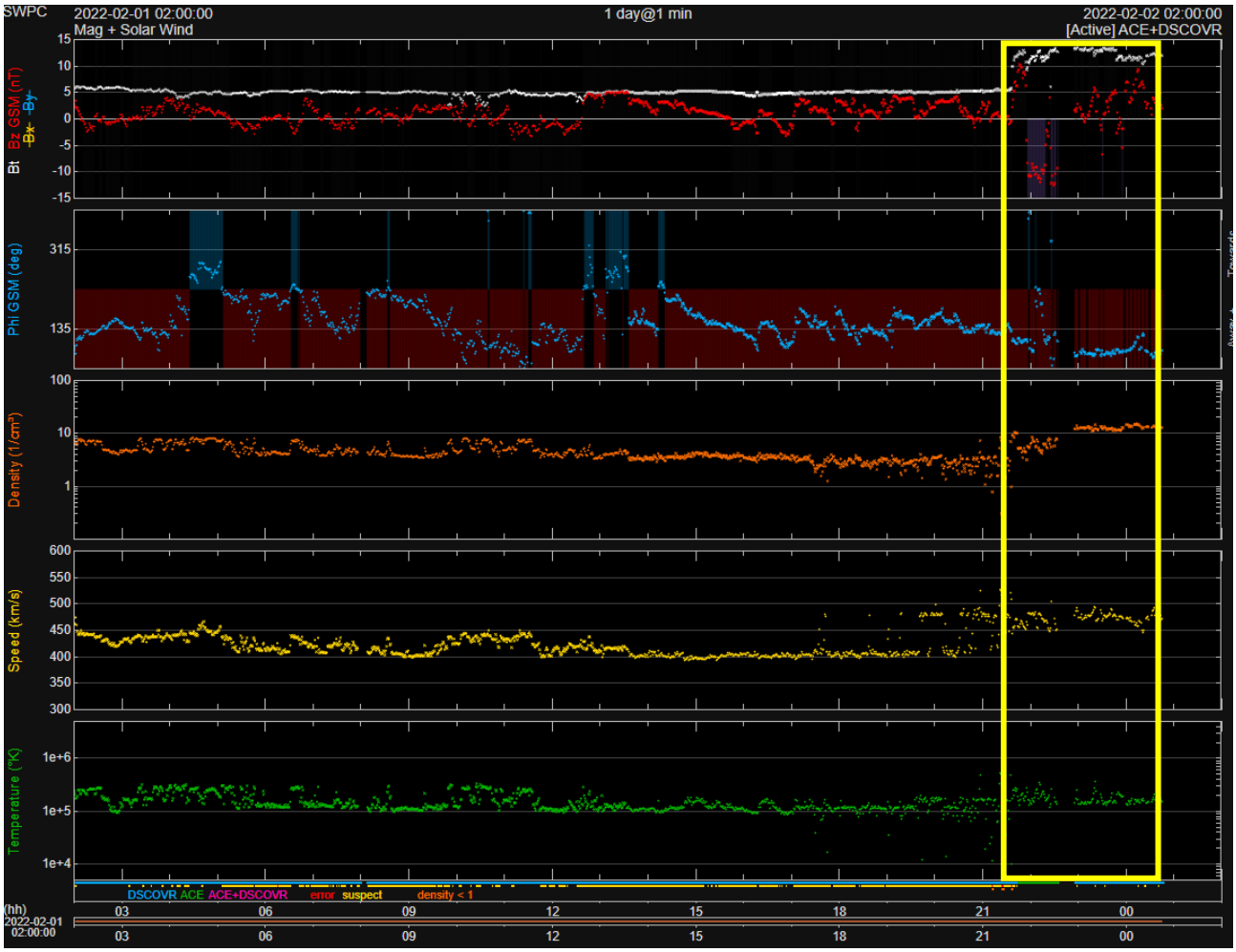
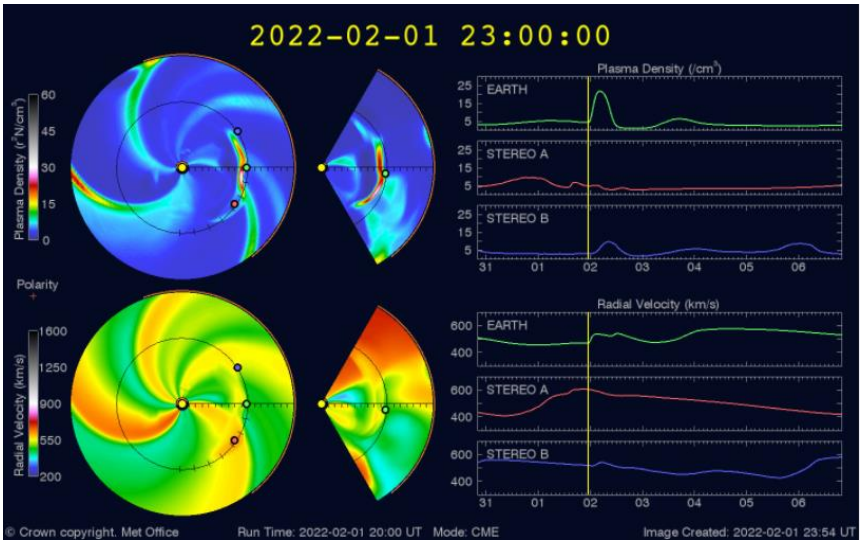


Figure 3: ENLIL shows the CME (left the Sun on the 29th Jan) forecast to arrive late on the 1st into the 2nd Feb.



Radio Blackouts - X-Ray Flares:

Solar activity is low, with frequent low level C-class flares, mainly from AR2940 and AR2939.

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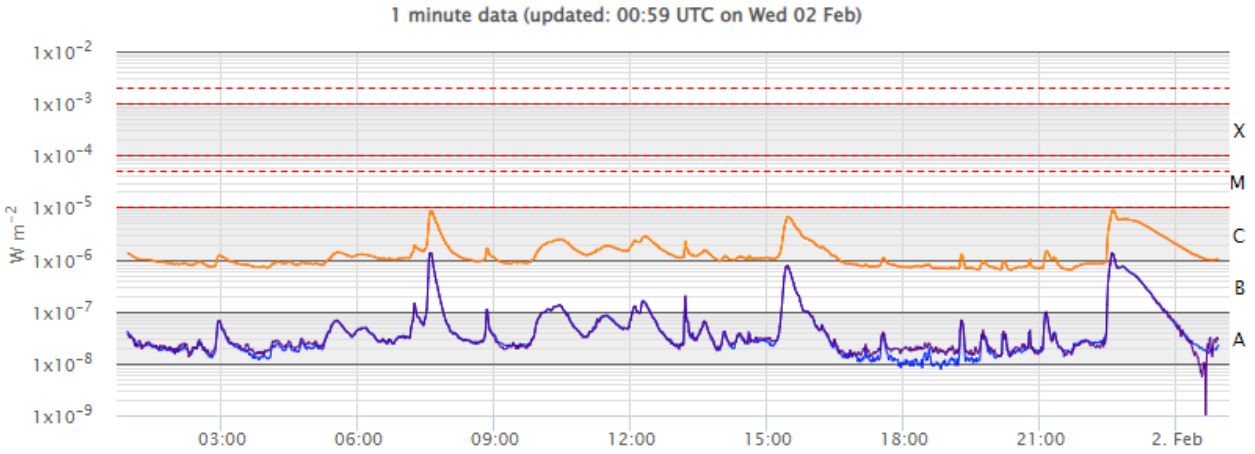
These two regions are so far only showing Beta-style magnetic arrangements, which keeps them stable and quiet, albeit AR2940 especially has a significant number of individual mature sunspot regions moving around in a compact fashion, which explains why this is the brightest region in the EUV spectrum. This region is the most likely to flare at M-class, whilst the others should remain at C-class.

AR2936 (Eho/Beta) in the northwest sector is the largest region, which has been mostly stable, until recently, when it produced a long duration C9 flare at 01/2236UTC and an associated plasma ejecta, which is likely to produce a CME, although still awaiting coronagraph imagery to confirm. This region may still pose a threat to proton storms due to its current Carrington location.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 4: GOES X-Ray flares.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux, as measured by GOES-16 is at background levels. Solar radiation storms are not likely in the period, however there is a slight chance (5%) for proton fluxes to rise given any significant flaring, predominately from AR2936 in the northwest quadrant if it becomes unstable and flares significantly.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	5	5
Very Active	**≥ S3 ***	No	1	1	1	1

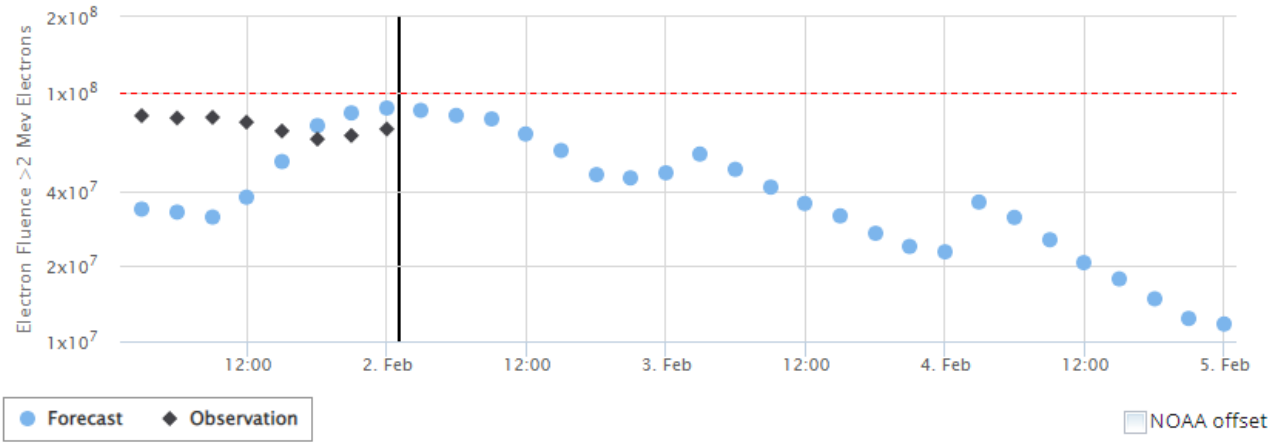
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) has been occasionally at high (1e3 pfu) levels recently with the recent high wind. The 24-hour fluence has topped out at 7.1e7pfu and is unlikely to rise any further during the next 2 days. The Geomagnetic activity from the arrival of the CME should tame these levels further, however the after-effects of the CME during days 3 and 4 may cause it to rise again, although with some uncertainty.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	20	20	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: REFM observation and forecast.



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